Docket No.: GPI-11602/38
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Utility Application of:
John E. Madocks

Application No.: 10/571,214

Confirmation No.: 2216

Filed: March 9, 2006

Art Unit: 1795

For: MAGNETIC MIRROR PLASMA SOURCE

Examiner: M. A. Band

PROPOSED AMENDMENTS

AMENDMENTS TO THE SPECIFICATION OF RECORD

Please amend the paragraph beginning on line 3 of page 5 as follows:

FIG. 1A shows a simple implementation of one preferred embodiment. Source 10 is located in a process chamber at a reduced pressure. A non-magnetic substrate 1 is placed over a magnet 5. A high permeability material such as steel serves as the cathode 3 and is positioned over substrate 1 at sufficient distance to allow a plasma to form between the cathode 3 and substrate 1. Anode 11 is a ring of wire positioned around the periphery of cathode 3. In this configuration, magnetic field lines 12 are formed between the magnet 5 and cathode 3. The field strength of these lines is stronger at the surface of the substrate 1 than at the cathode 3 forming a mirror magnetic field with the compressed end on the substrate 1. When a plasma voltage is impressed between cathode 3 and anode 11, a plasma 14 lights between the cathode 3 and substrate 1. In this embodiment, rather than the substrate 1 plasma facing surface <u>208</u> being held at cathode potential to reflect electrons, this surface <u>208</u> can be left electrically floating. <u>An opposing surface 210 exists in substrate 1 and is shown parallel to surface 208.</u> The electron containment is achieved by using the magnetic mirror effect The result is that electrons are

contained in all degrees of freedom by either magnetic and electrostatic Lorentz forces or by the magnetic mirror formed over the substrate. **{Please confirm no new matter issues with adding numbers – you are owed revised figures – (see attached)}**

Please amend the paragraph beginning on line 19 of page 5 as follows:

Referring now to FIGS. 1B and 1C, an electron 24 emitted from cathode surface 21 is confined to travel along magnetic field line 25. As the electron 24 moves along field line 25 from a region of weaker magnetic field Bo toward a stronger magnetic field Bm, the electron's axial velocity Va is converted to radial gyration velocity Vr around the field line 25 <u>and a longitudinal thermal velocity component Vt</u>. If the axial velocity Va component <u>Vt</u> reaches 0 before the electron 24 has encountered substrate 22, the electron 24 is reflected back toward the weaker field region. As the ratio of strong to weak magnetic field increases, more electrons are reflected. This magnetic mirror effect is greatly assisted in the preferred embodiments by the electric field surrounding the magnetic field. This is depicted in FIG. 1A by arrows 17 and dashed line 15. This electric field imposes a radial force on electrons that encourages the radial velocity and results in better electron containment by the mirror effect. This can be seen in FIG. 1B as a cone of bright plasma 27 surrounding the inner plasma region 26. **{Please confirm no new matter issues with Vt: vector physics requires it inherently to be present. Treatise text can be supplied if needed}**

Please amend the paragraph beginning on line 1 of page 6 as follows:

This embodiment uses these characteristics to confine a low pressure plasma for the processing of a substrate. In source 10, a rare earth magnet 5 is used to create a strong magnetic field region at the plasma facing surface <u>208</u> of substrate 1. Further from the magnet, the field progressively weakens and spreads out to cathode plate 3. When a voltage ranging from ~400V-2000V or higher is impressed between the cathode 3 and anode 11 and the chamber pressure is approximately between 3 and 100 mTorr, electrical breakdown occurs, and a plasma is maintained in region 14. As electrons are created either by secondary emission from the cathode 3 or by collisions in the plasma, they are confined within plasma region 14 and generate an endless Hall current within plasma 14. **{Please confirm no new matter issues with adding numbers}**

Please amend the paragraph beginning on line 4 of page 7 as follows:

Referring again to FIG. 1A, when the substrate is floated or connected to the electrode opposed to electrode 3, at least a portion of the magnetic mirror created between the plasma facing surface of substrate 1 and the plasma facing surface of cathode 3 must exceed a ratio of 2:1. This ratio is defined as the <u>magnetic</u> field strength at a point on the plasma facing surface of substrate 1 <u>denoted at 202</u> versus the strength of that same field line as it enters the cathode 3 surface <u>denoted at 204</u>. A weaker ratio than 2:1 results in too few electrons being reflected by the magnetic mirror, and a low pressure plasma cannot be sustained. **{Please confirm no new matter issues with adding numbers to ratio that was already present}**

Please amend the paragraph beginning on line 1 of page 10 as follows:

FIG. 2A shows an embodiment configured for ionized physical vapor deposition ("IPVD") onto round planar substrates such as silicon wafers. Wafer 76 is placed on non-magnetic stage 75. A magnetic field 78 is passed through the wafer, through the gap between the wafer and sputter target 83 to cover 72. Target 83 is bonded to cover 72 to improve thermal conductivity between target 83 and cover 72. Cover 72 is made of a high permeability material such as 400 series stainless steel and is water cooled. Wafer stage 75 is also water cooled. Water cooling of sputter sources is well known in the art and details are not shown. The magnetic field 78 in the gap between the substrate 76 and target 83 is generated by magnet array 80 and is assisted by high permeability members cover 72, steel shunt circle 81, shunt 74. Shunt 74 and magnet array 80 rotate under the stationary platen 75 to obtain a uniform coating on substrate 76. Power supply 70 is connected between cover 72 and shunt 81 <u>to create an electric field 79</u>. This can be a DC, pulsed DC, AC or RF power supply. **{Please confirm no new matter issues with adding number 79, electric filed inherently}**

Please amend the paragraph beginning on line 9 of page 11 as follows:

In the FIGS. 2A, 2B <u>and</u> 2C~~, 2D~~ source, the magnet material is a rare earth type. The field 78 produced between the wafer and electrode 72 is greater than 100 gauss--in other words, the plasma electrons are "magnetized" in the gap. Using today's materials, it is relatively easy to increase the magnetic field strength to also magnetize the plasma ions. This requires a magnetic field strength nearing or greater than 1000 G. The plasma of the method of the preferred

embodiment adapts well to ion magnetization because there are no cathode surfaces to interrupt a larger gyro radius as with a planar magnetron type confinement.

Please amend the paragraph beginning on line 11 of page 16 as follows:

FIG. 6 depicts another sputter source embodiment. In this source, two magnets are disposed across a gap. Sputter cathode electrode 45 is located approximately in the center of the gap. Electrode 45 is constructed of copper, stainless steel, titanium or other non-magnetic material to be sputtered. As can be seen, a mirror magnetic field is generated with the compressed field passing through the substrate 41 and the less compressed field passing through the cathode electrode 45. When voltage from a power supply 42 is impressed across the cathode electrode 45 and a ring anode 43 such that electric fields penetrate into the magnetic field sufficiently, the electron Hall current is contained within the magnetic field. With sufficient voltage and process gas pressure, a plasma 44 is formed between the cathode and substrate. FIG. 6 illustrates that magnetic arrangements other than a high permeability cathode can be implemented. In this source, target 45 is bonded to water cooled backing plate 48. **{Please confirm no new matter issues with adding number 42}**

AMENDMENTS TO THE CLAIMS

1. (Proposed amended) A plasma source apparatus comprising:

a substrate having a first surface and an opposing surface;

a second surface, said second surface being spaced apart from said first surface by a predetermined gap, connected to a power supply as a cathode;

a third surface connected to the power supply as an anode;

a magnetic field source providing a magnetic field axial {**intention of this language is magnet with pole aligned axial with field (See application Figs 1A-1D), please confirm interpretation accorded to this term**} with said magnetic field source, said magnetic field passing into both said first and second surfaces and through said gap, said magnetic field having a portion passing through said substrate is at least two times stronger at said first surface than at said second surface, said magnetic field portion having a strength strong enough to magnetize electrons; and

an electric field extending to said second surface and said electric field penetrating into an electron confining region of said magnetic field.

Tateishi : magnet is annular ring (30 + 33) with N pole closer to substrate relative to S pole. This yields a bridged plasma field through the central return filed lines as shown below. Also, fig. 8 shows that field lines at substrate cannot be 2X> than at cathode.

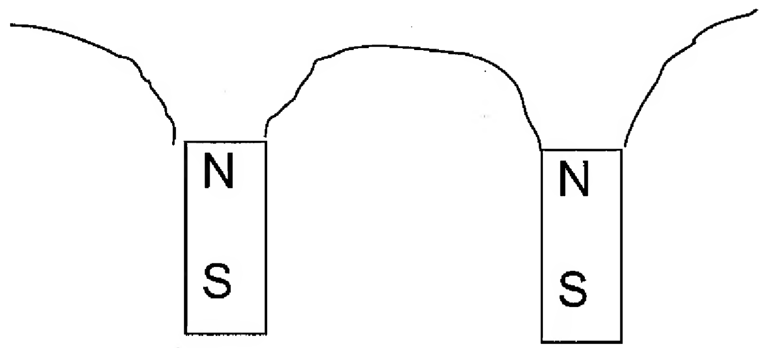


FIG. 8

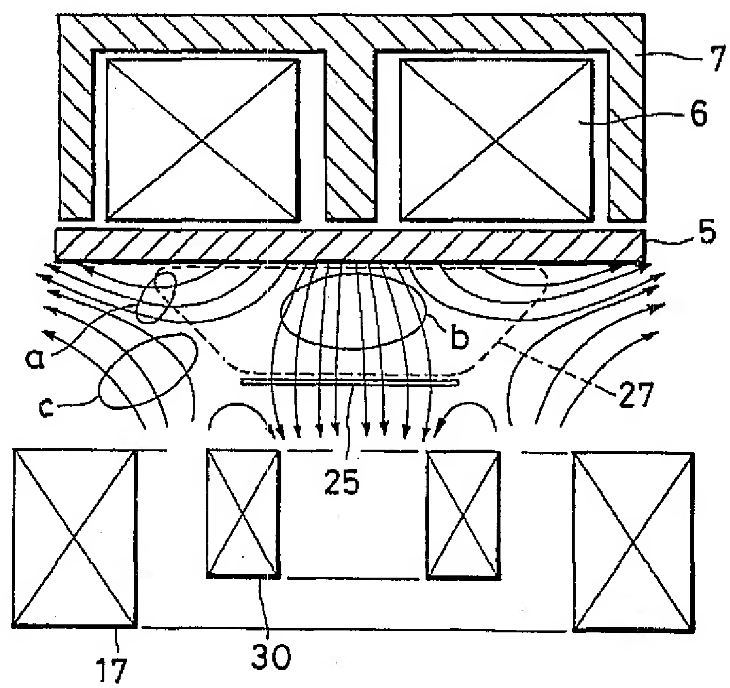
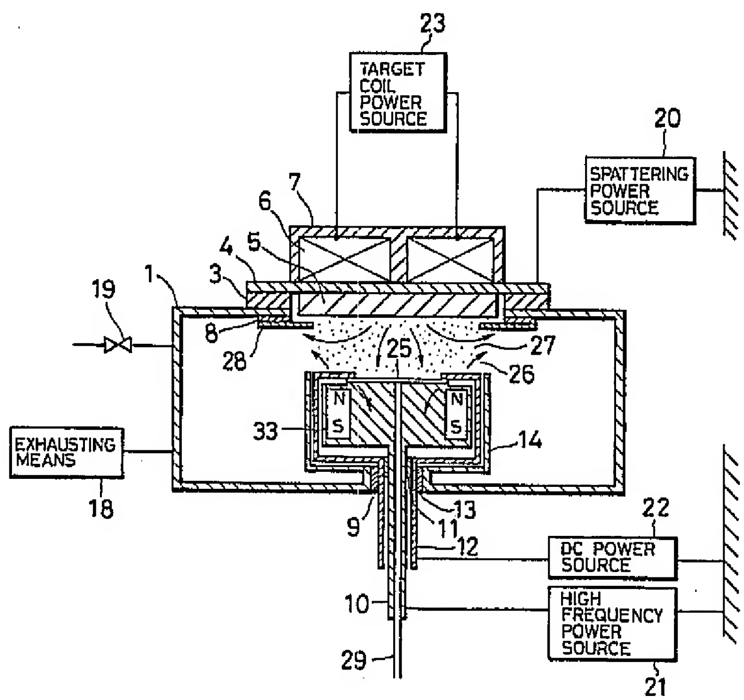


FIG. 10



21. (Proposed amendment per claim 1 above) A plasma source apparatus comprising:

a substrate having a first surface and an opposing surface;

a second surface, said second surface being spaced apart from said first surface by a predetermined gap, connected to a power supply as a cathode;

a third surface connected to the power supply as an anode;

a permanent magnet under said substrate providing a magnetic field axial with said permanent magnet under said substrate, said magnetic field passing into both said first and second surfaces and through said gap, said magnetic field having a portion passing through said substrate is at least two times stronger at said first surface than at said second surface, said magnetic field portion having a strength strong enough to magnetize electrons; and

an electric field extending to said second surface and said electric field penetrating into an electron confining region of said magnetic field.

24. (Previously presented) A plasma source apparatus in accordance with claim 21, comprising:

relative movement between said substrate moving continuously relative to said magnetic field.

28. (Previously presented) A plasma source apparatus in accordance with claim 21, wherein:

said substrate comprises a flexible web supported by a conveyor roll.

29. (Previously presented) A plasma source apparatus in accordance with claim 21, comprising:

a mirror field shaped into a racetrack and having a return field passing through the center of the racetrack.

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Proposed Amended

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FIG. 1A

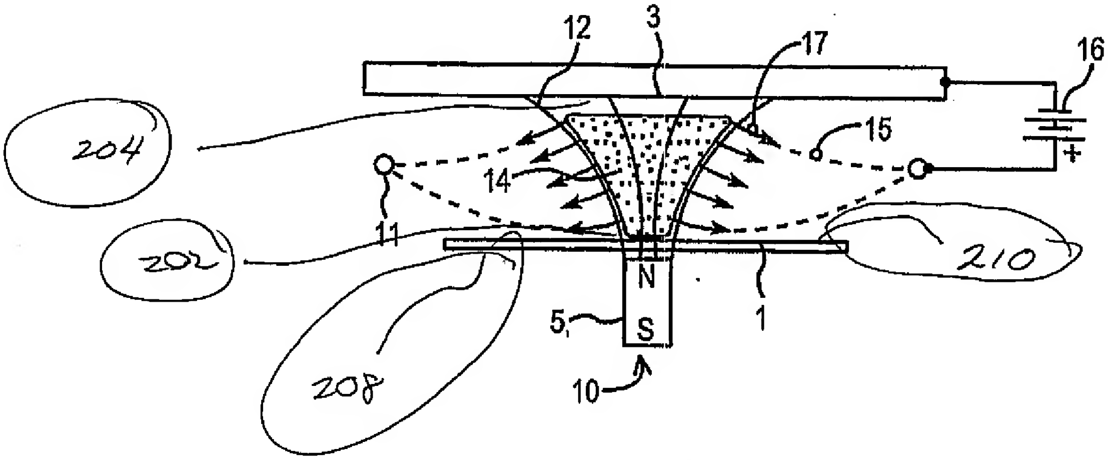


FIG. 1B

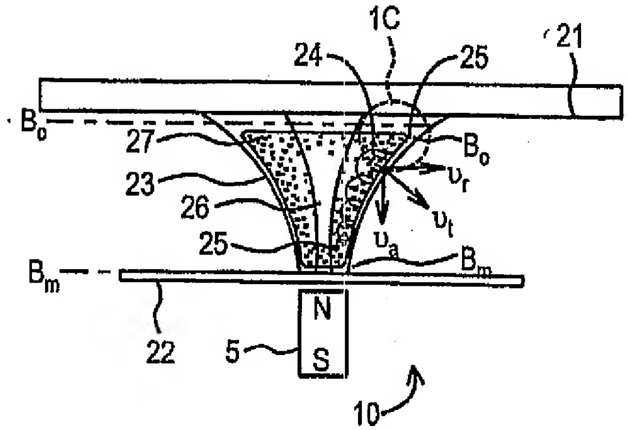
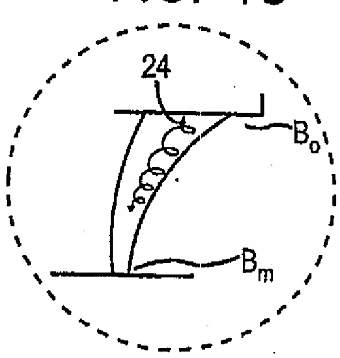


FIG. 1C



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